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Owaki et al.

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(54) **LIQUID EJECTING APPARATUS**

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(52) **U.S. Cl.**
CPC ***B41J 2/17596*** (2013.01); *B41J 2/17563* (2013.01); ***B41J 2/18*** (2013.01)

(58) **Field of Classification Search**
USPC 347/84–85, 89, 93
See application file for complete search history.

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Primary Examiner — Anh T. N. Vo

(57) **ABSTRACT**

A liquid ejecting apparatus includes a liquid ejecting head that ejects liquid in a manifold as liquid droplets from a nozzle opening; a supply path that supplies the liquid to the manifold; a pump unit that is disposed in the supply path and pumps the liquid; and a discharge path that discharges the liquid from the manifold, wherein a flow path resistance of the discharge path from the manifold is smaller than a flow path resistance of the supply path from the pump unit to the manifold.

12 Claims, 10 Drawing Sheets

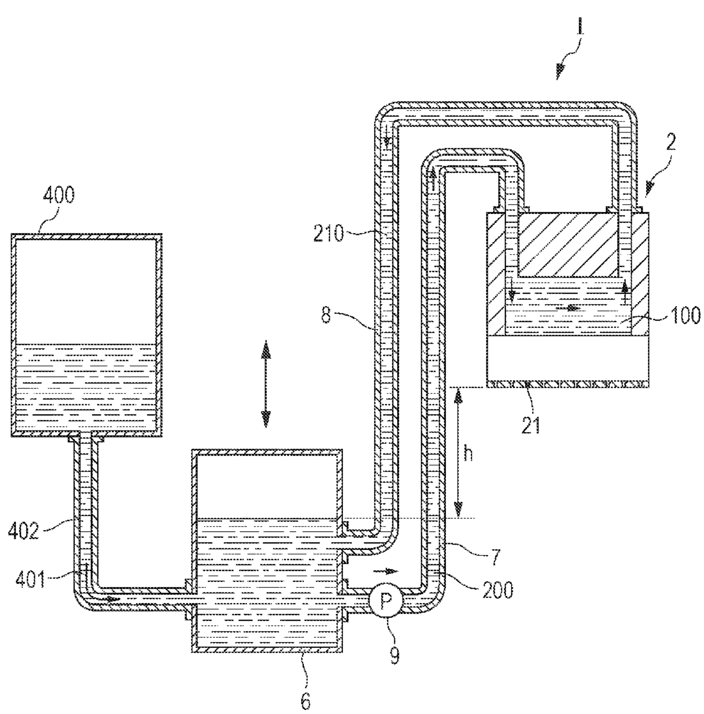


FIG. 1

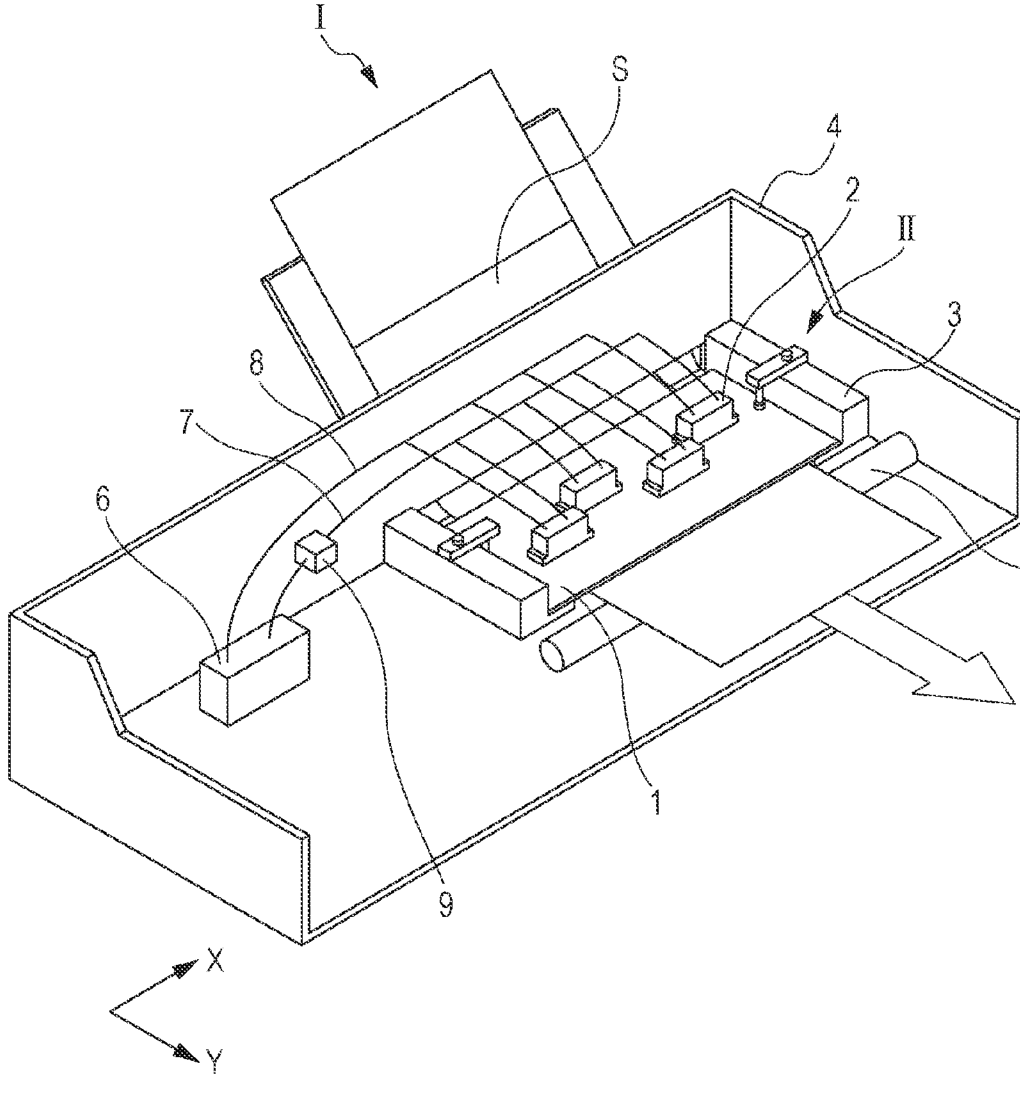


FIG. 2

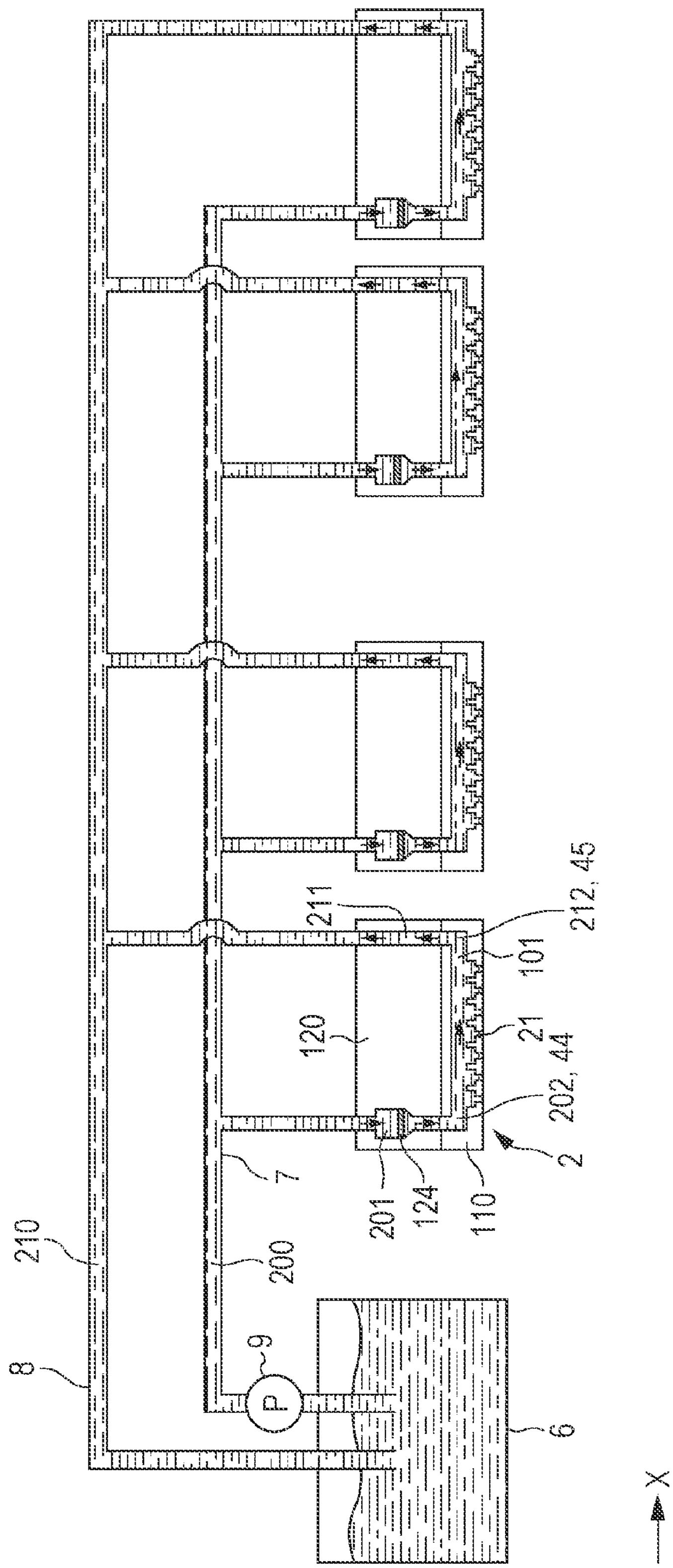


FIG. 3

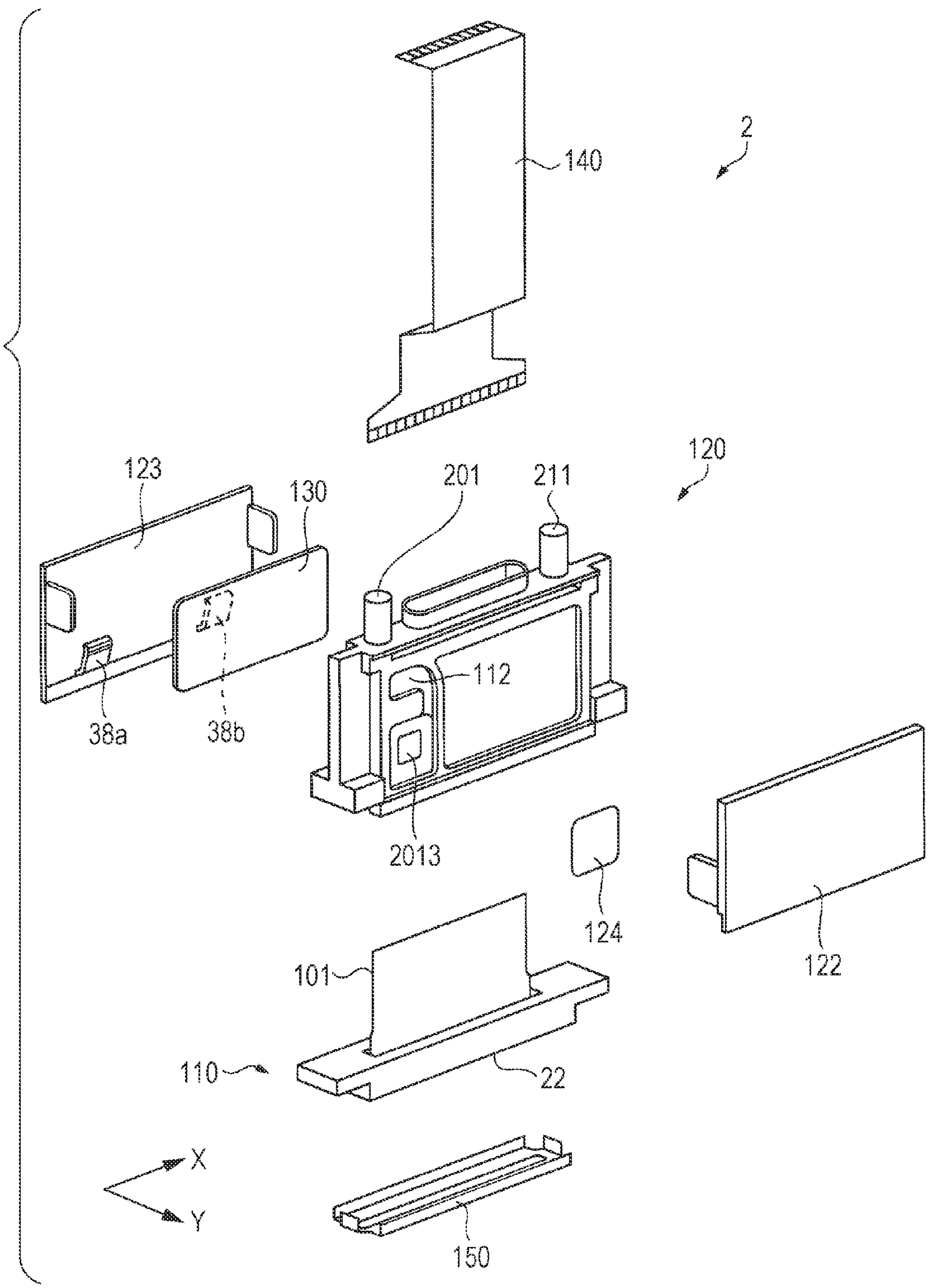

2
140
120
123
130
201
211
112
38a
38b
2013
124
122
101
110
22
X
Y
150

FIG. 4

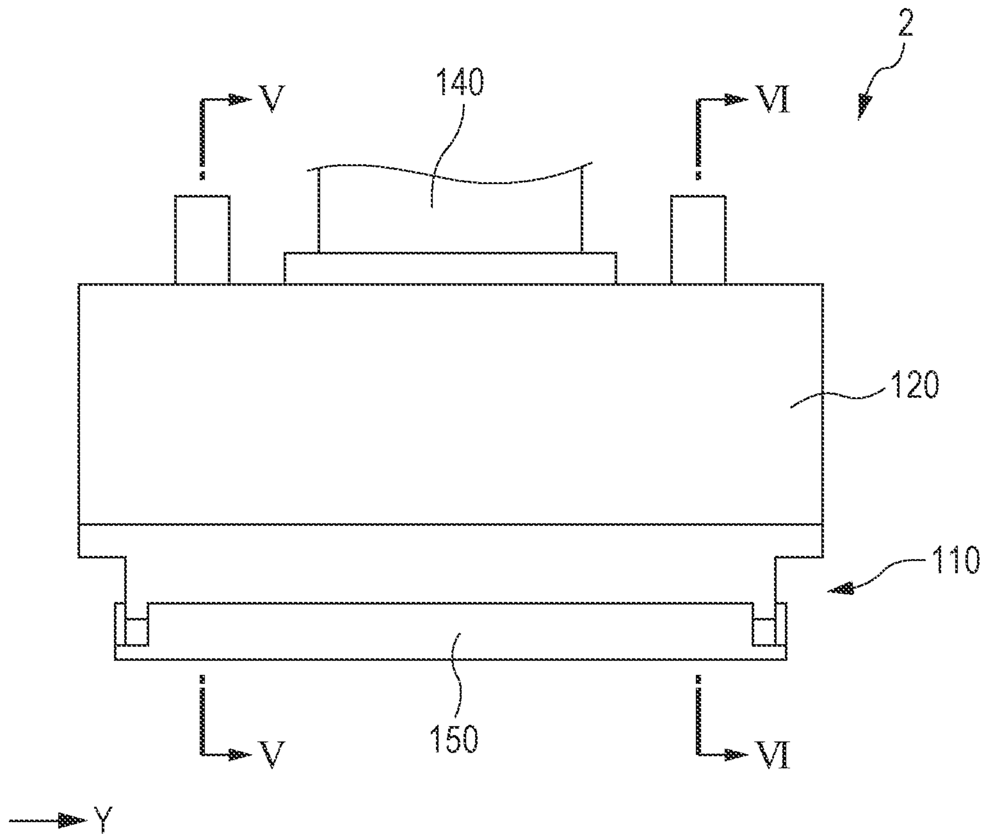


FIG. 5

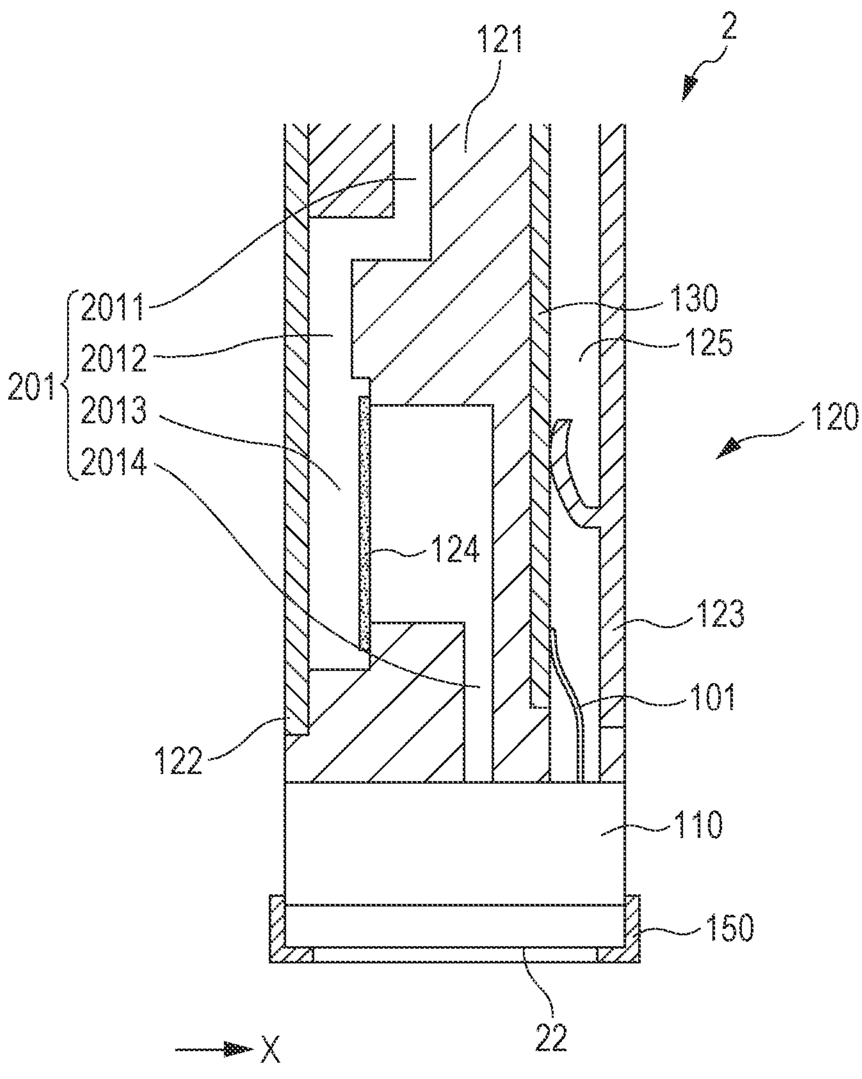

121
2
2011
2012
2013
2014
201
130
125
120
124
123
101
122
110
150
22
X

FIG. 6

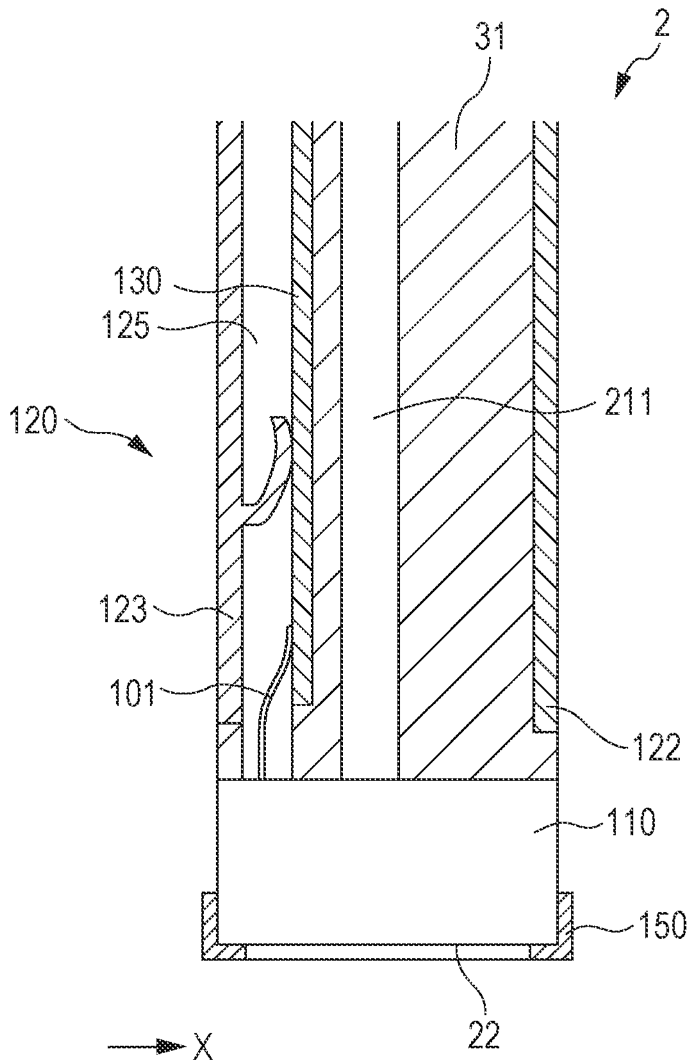


FIG. 7

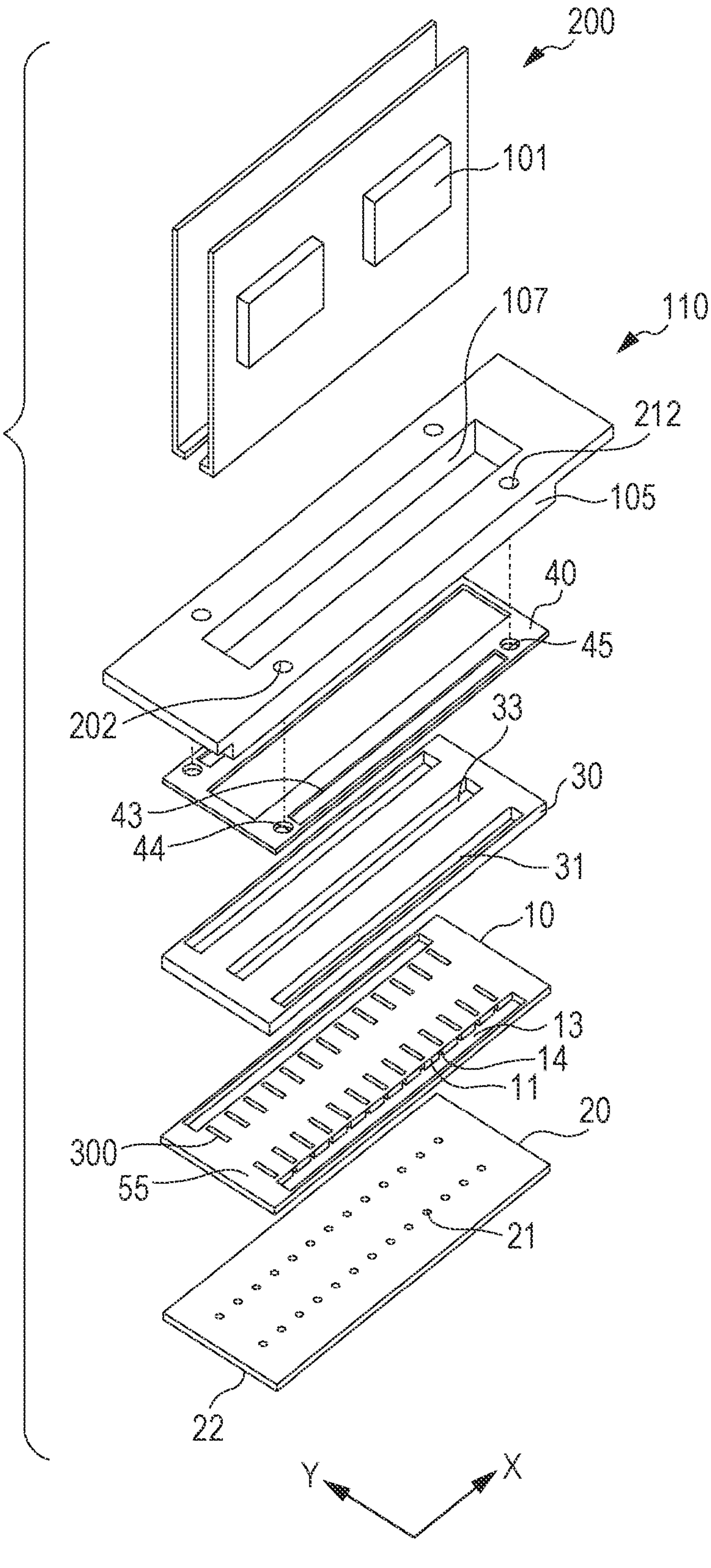
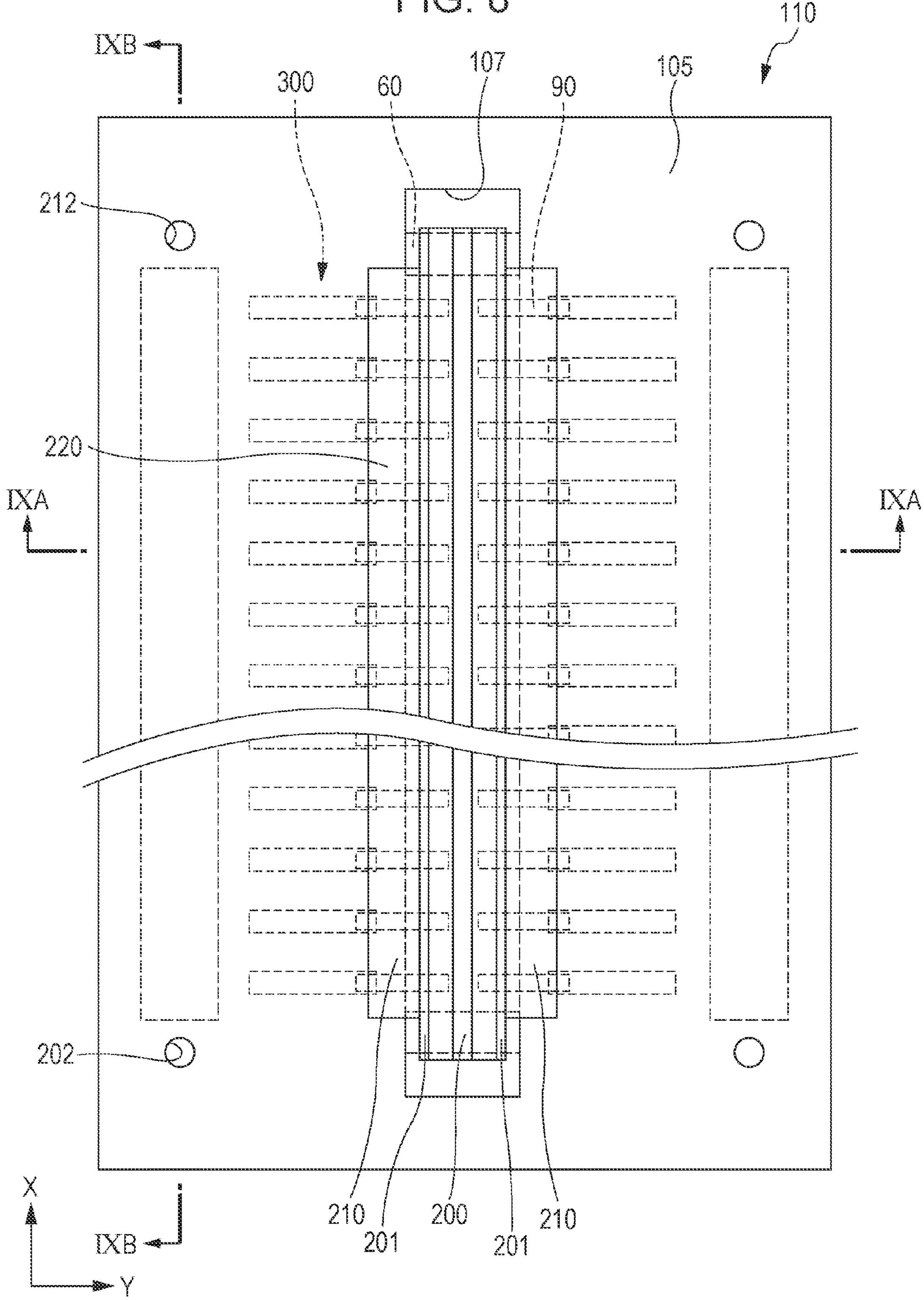

200
101
107
110
212
105
40
45
202
33
30
43
44
31
10
13
14
11
20
300
55
21
22
Y
X

FIG. 8



110
IXB
107
300
60
90
105
212
220
IXA
IXA
202
X
IXB
Y
210
201
200
201
210

FIG. 9A

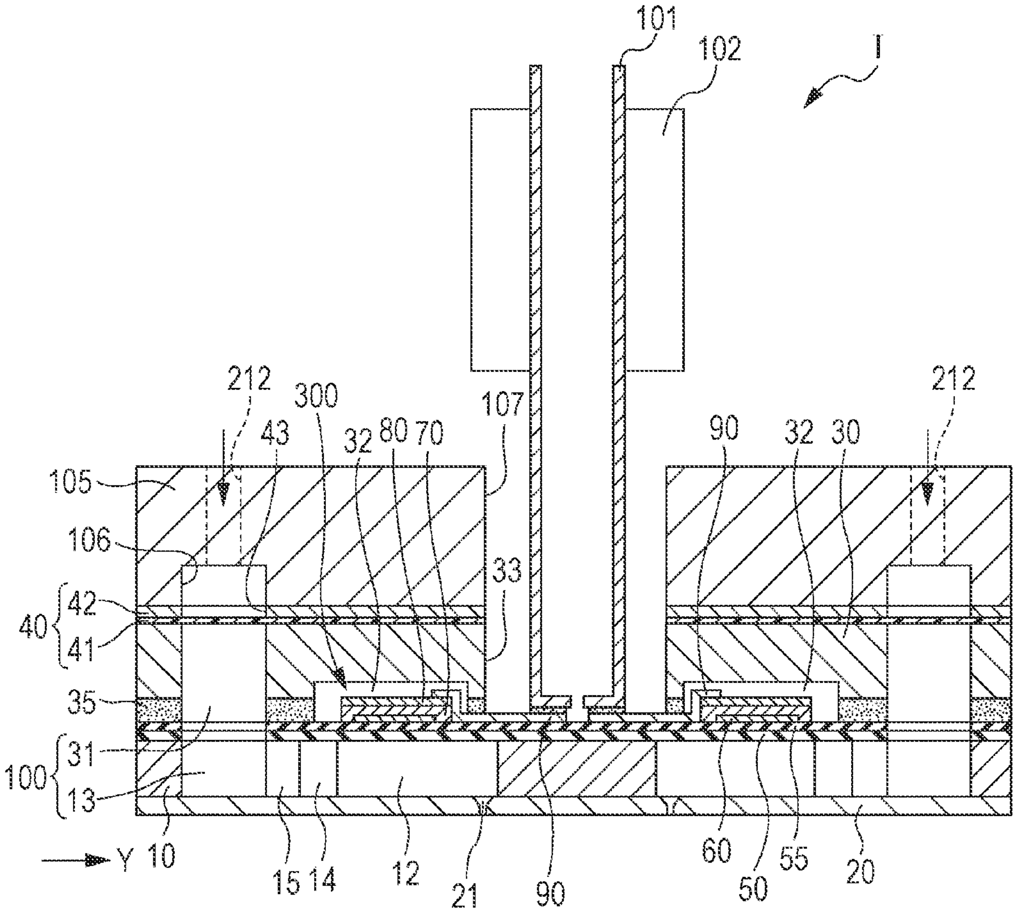

101
102
I
212
300
43
32
80
70
107
90
32
30
212
105
106
33
40
42
41
35
31
100
13
10
15
14
12
21
90
60
50
55
20
Y

FIG. 9B

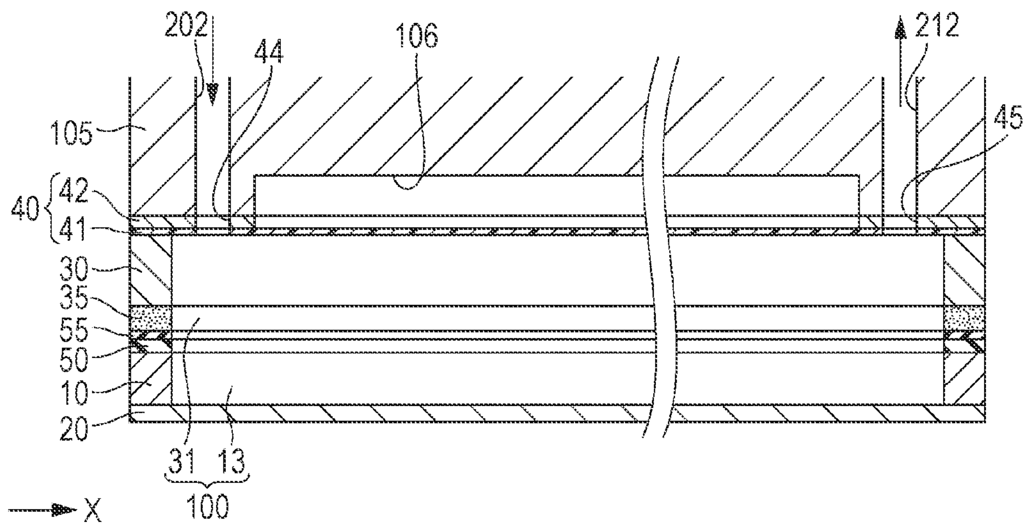
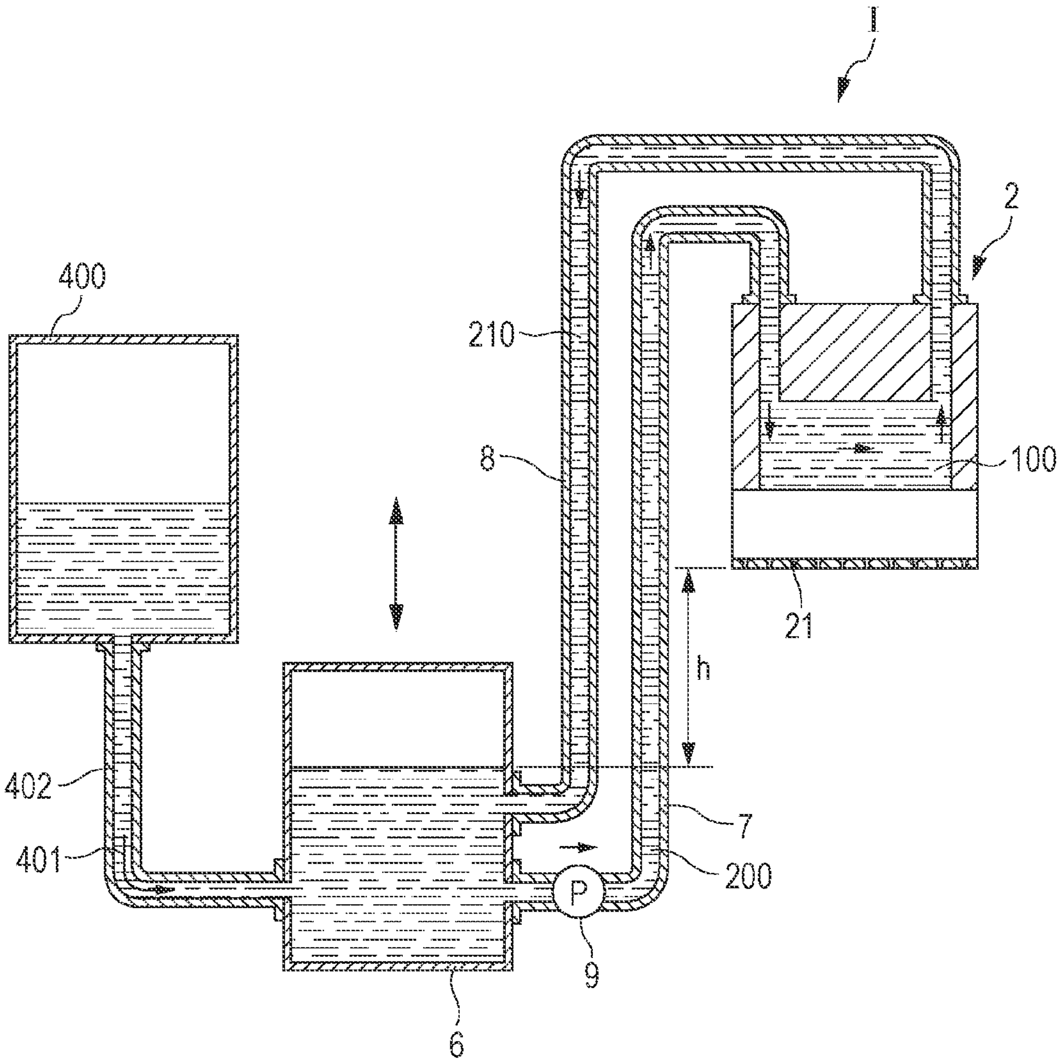

202
44
106
212
45
105
40
42
41
30
35
55
50
10
20
31
13
100
X

FIG. 10



LIQUID EJECTING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to Japanese Patent Application No. 2012-227347 filed on Oct. 12, 2012. The entire disclosure of Japanese Patent Application No. 2012-227347 is incorporated herein by reference.

BACKGROUND

1. Technical Field

The present invention relates to liquid ejecting apparatuses having a liquid ejecting head that ejects liquid from nozzle openings, and more specifically to ink jet recording apparatuses having an ink jet recording head that ejects ink as liquid droplets.

2. Related Art

Liquid ejecting apparatuses having a liquid ejecting head that ejects liquid include ink jet recording apparatuses having an ink jet recording head that generates a pressure in flow paths by using pressure generating means and ejects ink droplets from nozzle openings that communicate with the flow paths.

Such an ink jet recording head has a problem of ejection failure such as clogging of nozzle openings due to thickening of ink, sedimentation of ink components and containment of air bubbles. JP-A-2012-56248 discloses a liquid ejecting apparatus including a supply path that supplies ink stored in a liquid storing unit to a manifold which is a common liquid chamber for all the flow paths that communicate with the respective nozzle openings of an ink jet recording head, and a discharge path that discharges ink which is thickened and contains sediments of ink components and air bubbles from the manifold of the ink jet recording head to the outside.

However, in a configuration in which ink is supplied from the outside to the ink jet recording head and is discharged from the ink jet recording head to the outside, the consumption of ink ejected at a time differs between when ink droplets are ejected from all the nozzle openings and when ink droplets are ejected from one nozzle opening. This causes a pressure change in the manifold and leads to a problem in that the weight of ejected ink droplets varies.

Such a problem is not limited to the ink jet recording apparatuses and exists in the liquid ejecting apparatuses that eject liquid other than ink.

SUMMARY

An advantage of some aspects of the invention is that the liquid ejecting apparatus that is capable of preventing the weight of ejected liquid droplets from varying depending on the consumption of liquid ejected at a time, and preventing uneven application of the liquid is provided.

According to an aspect of the invention, a liquid ejecting apparatus includes a liquid ejecting head that ejects liquid in a manifold as liquid droplets from a nozzle opening; a supply path that supplies the liquid to the manifold; a pump unit that is disposed in the supply path and pumps the liquid; and a discharge path that discharges the liquid from the manifold, wherein a flow path resistance of the discharge path from the manifold is smaller than a flow path resistance of the supply path from the pump unit to the manifold. Accordingly, since the flow path resistance of the discharge path is decreased, a pressure in the manifold can be prevented from varying depending on the amount of liquid ejected at a time. As a result, the difference in the weight of ejected liquid can be reduced, thereby preventing uneven application of the liquid. Further, since the liquid is pumped by using the pump unit, the liquid can be supplied under a high pressure.

In the above aspect, a filter that traverses the supply path is preferably disposed in the supply path at a position between the pump unit and the manifold. With use of the filter, the flow path resistance of the supply path becomes larger than the flow path resistance of the discharge path.

Further, the flow path resistance may be adjusted by adjusting the amount of cross-sectional area of the supply path and the discharge path.

It is preferable that the liquid ejecting apparatus further includes a liquid storing unit, wherein the pump unit pumps the liquid stored in the liquid storing unit via the supply path, and the discharge path discharges the liquid from the manifold to the liquid storing unit. Accordingly, a circulation flow path can be formed.

It is preferable that the liquid ejecting apparatus further includes a supply liquid storing unit, wherein the pump unit pumps the liquid stored in the supply liquid storing unit via the supply path.

It is preferable that the liquid ejecting apparatus further includes a discharge liquid storing unit, wherein the discharge path discharges the liquid from the manifold to the discharge liquid storing unit.

It is preferable that the supply liquid storing unit and the discharge liquid storing unit are connected with each other. Accordingly, a circulation flow path can be formed.

It is preferable that the liquid ejecting apparatus further includes a plurality of liquid ejecting heads, wherein the supply path that supplies the liquid from the pump unit to the liquid ejecting head is divided into branches. With this configuration, the liquid can be supplied to a plurality of liquid ejecting heads by using one pump unit, thereby eliminating the need of a plurality of pump units and reducing the cost. Further, a difference in the pressure in the manifolds of the plurality of liquid ejecting heads can be reduced, thereby preventing the weight of liquid ejected from the plurality of liquid ejecting heads from varying.

It is preferable that pressure adjustment of a liquid meniscus at the nozzle opening is performed by using a water head difference between a liquid ejection surface to which the nozzle opening is open and the liquid storing unit. With this configuration, pressure adjustment can be performed without a negative pressure pump or the like, thereby reducing the cost.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** is a perspective view which shows a schematic configuration of a recording apparatus according to a first embodiment.

FIG. **2** is a sectional view which shows a schematic configuration of the recording apparatus according to the first embodiment.

FIG. **3** is an exploded perspective view of a recording head according to the first embodiment.

FIG. **4** is a plan view of the recording head according to the first embodiment.

FIG. **5** is a sectional view of the recording head according to the first embodiment.

FIG. **6** is a sectional view of the recording head according to the first embodiment.

FIG. **7** is an exploded perspective view of a head body according to the first embodiment.

FIG. **8** is a plan view of the head body according to the first embodiment.

FIGS. **9**A and **9**B are sectional views of the head body according to the first embodiment.

FIG. **10** is a sectional view which shows a schematic configuration of a recording apparatus according to other embodiments.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

The invention will be described below in detail based on embodiments.

First Embodiment

FIG. **1** is a perspective view which shows a schematic configuration of an ink jet recording apparatus which is an example of liquid ejecting apparatus according to a first embodiment. FIG. **2** is a sectional view which shows a schematic configuration of the ink jet recording apparatus.

As shown in FIG. **1**, an ink jet recording apparatus I which is an example of liquid ejecting apparatus of this embodiment is a so-called line-type ink jet recording apparatus in which a head unit II is fixedly attached on an apparatus body **4** and has a plurality of ink jet recording heads **2** so that printing is performed when a recording medium such as a recording sheet S is transported in a transporting direction.

The head unit II includes a base plate **1** and the plurality of ink jet recording heads **2** that are held by the base plate **1**. A nozzle plate which is an ink ejection surface of the ink jet recording heads **2** is provided on one side of the base plate **1**. The base plate **1** is fixedly attached on the apparatus body **4** via a frame member **3**.

A sheet feeding roller **5** is disposed in the apparatus body **4**. The sheet feeding roller **5** feeds the recording sheet S such as a sheet of paper which is fed to the apparatus body **4** so that the recording sheet S passes on the side of the ink ejection surface of the ink jet recording heads **2**. In the head unit II, four ink jet recording heads **2** are arranged in a direction which is perpendicular to the transporting direction of the recording sheet S. An arrangement direction of nozzle openings (first direction X) is an arrangement direction of the four ink jet recording heads **2**, which will be described in detail later.

Further, in the ink jet recording apparatus I, a liquid storing unit **6** such as an ink tank that stores ink is fixedly attached on the apparatus body **4**. The liquid storing unit **6** is connected to a supply tube **7** that supplies ink to the ink jet recording heads **2** and a discharge tube **8** that discharges (recovers) ink from the ink jet recording heads **2**.

The supply tube **7** and the discharge tube **8** are made of a tubular member such as a flexible tube and have a first supply path **200** for supplying ink and a first discharge path **210** for discharging ink, respectively. Further, a pump unit **9** such as a pump is disposed at a position on the supply tube **7** so as to pump ink from the liquid storing unit **6** to the ink jet recording heads **2**.

In this embodiment, as shown in FIG. **2**, the supply tube **7** (first supply path **200**) is divided into branches at downstream to the pump unit **9** so that ink is pressurized by a single pump unit **9** and is supplied to the plurality of ink jet recording heads **2**.

Then, ink in the liquid storing unit **6** is supplied to the ink jet recording heads **2** via the first supply path **200**, and ink which is not ejected from the nozzle openings is recovered to the liquid storing unit **6** via the first discharge path **210**. In this embodiment, ink which is stored in the liquid storing unit **6** is supplied to the ink jet recording heads **2** via the first supply path **200**, and ink which is discharged from the ink jet recording heads **2** is discharged into the liquid storing unit **6** via the first discharge path **210**. Accordingly, the first supply path **200** and the first discharge path **210** form part of a circulation flow path through which ink flows between the liquid storing unit **6** and the ink jet recording heads **2**.

An example of the ink jet recording head **2** which is mounted on the ink jet recording apparatus I will be described in detail below. FIG. **3** is an exploded perspective view of the ink jet recording head **2** which is an example of liquid ejecting head according to the first embodiment. FIG. **4** is a plan view of the ink jet recording head **2**. FIG. **5** is a sectional view of an essential part of the ink jet recording head **2** taken along the line V-V of FIG. **4**. FIG. **6** is a sectional view of an essential part of the ink jet recording head **2** taken along the line VI-VI of FIG. **4**.

As illustrated, the ink jet recording head **2** which is an example of liquid ejecting head of this embodiment includes a head body **110** that ejects ink droplets as an example of liquid, a flow path member **120** that supplies ink to the head body **110**, a circuit substrate **130** that is held by the flow path member **120**, and a wiring substrate **140** that is connected to the circuit substrate **130**.

The head body **110**, which will be described in detail later, is configured to eject the supplied ink as ink droplets from the nozzle openings and includes flow paths that communicate with nozzle openings and pressure generating means such as a piezoelectric actuator that generates pressure change in ink in the flow paths.

The head body **110** includes a drive wiring **101** which is a flexible wiring member whose one end is connected to the piezoelectric actuator (pressure generating means). The drive wiring **101** may include, for example, a drive circuit (drive IC) that drives the piezoelectric actuator (pressure generating means). That is, the drive wiring **101** may be a COF substrate on which a drive circuit is mounted.

A cover head **150** is fixedly attached on the liquid ejection surface **22** so as to protect the nozzle openings of the head body **110** which are open to the liquid ejection surface **22**.

The flow path member **120** includes a flow path body **121**, and a first cover **122** and a second cover **123** which are disposed on each side of the flow path body **121**.

Further, the flow path member **120** includes a second supply path **201** that communicates with the first supply path **200** of the liquid storing unit **6** (see FIG. **1**) that stores ink as an example of liquid so as to supply ink to the head body **110** and a second discharge path **211** that discharges ink from the head body **110** to the first discharge path **210**.

The second supply path **201** of the ink jet recording head **2** includes an introduction port **2011** that communicates with the first supply path **200**, a first flow path **2012** that communicates with the introduction port **2011**, a filter chamber **2013** that communicates with the first flow path **2012**, a second flow path **2014** that connects the filter chamber **2013** to the head body **110**.

As shown in FIG. **5**, the first flow path **2012** and the filter chamber **2013** are formed as a channel, one side of which is open to the surface of the flow path body **121** (on the side of the first cover **122**). The openings of the first flow path **2012** and the filter chamber **2013** are closed by the first cover **122**.

The second flow path **2014** has one end which is connected to the filter chamber **2013** and the other end which is connected to the flow path of the head body **110**.

Further, a filter **124** is disposed in the filter chamber **2013** so as to filter out foreign substances such as dust and air bubbles contained in the ink. The filter **124** is configured to filter out foreign substances such as dust and air bubbles contained in the ink which is an example of liquid and may be, for example, a sheet member having a plurality of micropores formed by finely braided metal or resin fibers, or a metal or resin plate member having a plurality of micropores which penetrate the plate member. The filter **124** may be made of a non-woven fiber or any other materials.

The flow path body **121** also includes a recess **125** that is open to the surface of the flow path body **121** on the side of the second cover **123** which is opposite to the first cover **122** where the first flow path **2012** and the filter chamber **2013** are open. The circuit substrate **130** is inserted into the recess **125** of the flow path body **121**. Then, the circuit substrate **130** inserted into the recess **125** is held between the flow path body **121** and the second cover **123** that closes the opening of the recess **125**.

The circuit substrate **130** is formed by a printed substrate on which electronic elements and wiring, which are not shown in the figure, are provided. The circuit substrate **130** is electrically connected to the drive wiring **101** of the head body **110** and a wiring substrate **140**, which is not shown in the figure. Accordingly, print signals from an external control circuit or the like are supplied as drive signals to the piezoelectric actuator, which will be described later, via the wiring substrate **140**, the circuit substrate **130** and the drive wiring **101**. Further, signals from the circuit substrate **130** (temperature information, which will be described later) are transmitted to the external control circuit or the like via the wiring substrate **140**. The circuit substrate **130** may be either a flexible substrate or a rigid substrate, or a composite substrate made of a combination of a flexible substrate and a rigid substrate.

The circuit substrate **130** is held in the recess **125** of the flow path body **121** between the flow path body **121** and the second cover **123**.

As shown in FIG. **6**, the second discharge path **211** disposed in the flow path member **120** is configured to recover the ink which has been supplied to the head body **110** (manifold) back to the liquid storing unit **6**. The second discharge path **211** is disposed on an end which is opposite to the second supply path **201** of the flow path member **120**.

The second discharge path **211** penetrates a surface of the flow path member **120** on the side of the head body **110** and a surface opposite to the head body **110**, as shown in FIG. **6**.

In the ink jet recording head **2** of this embodiment, ink is supplied from the liquid storing unit **6** which is shown in FIG. **1** via the second supply path **201** in the flow path member **120** to the manifold in the head body **110**, which will be described in detail later, so that inside of the path from the manifold to the nozzle openings is filled with ink. After that, the piezoelectric actuator is actuated in response to recording signals from the drive circuit or the like, thereby ejecting ink droplets from the nozzle openings. Further, ink which has been supplied in the manifold in the head body **110** is returned to the liquid storing unit **6** via the second discharge path **211** of the flow path member **120**. That is, ink in the liquid storing unit **6** is supplied to the head body **110** via the first supply path **200** and the second supply path **201**, and is then discharged from the head body **110** to the liquid storing unit **6** via the second discharge path **211** and the first discharge path **210**.

An example of the head body **110** of this embodiment will be described in detail with reference to FIGS. **7** to **9**B. FIG. **7** is an exploded perspective view of the head body **110** according to the first embodiment of the invention. FIG. **8** is a plan view of the head body **110**. FIG. **9**A and FIG. **9**B are sectional views of the head body **110** taken along the line IXA-IXA and IXB-IXB of FIG. **8**, respectively.

As illustrated, a flow path forming substrate **10** constitutes the ink jet recording head **2** which is an example of the liquid ejecting head of this embodiment. On the flow path forming substrate **10**, a plurality of pressure generating chambers **12** separated by walls **11** are arranged side by side in the arrangement direction of a plurality of nozzle openings **21** that eject ink of the same color. This direction is hereinafter referred to as an arrangement direction of the pressure generating chamber **12** or the first direction X. Moreover, a plurality of rows (in this embodiment, two rows) of the pressure generating chambers **12** which are arranged side by side in the first direction X are disposed on the flow path forming substrate **10**. The arrangement direction of the rows of the pressure generating chambers **12** in which the pressure generating chambers **12** are arranged in the first direction X is hereinafter referred to as a second direction Y.

Further, communication sections **13** are formed on the outside of the pressure generating chambers **12** in the second direction Y such that the communication sections **13** communicate with each of the pressure generating chambers **12** via ink supply paths **14** and communication paths **15** which are provided for each of the pressure generating chamber **12**. The communication sections **13** communicate with manifold sections **31** of the protective substrate **30**, which will be described later, so as to form part of manifolds **100** which serve as a common ink chamber of the pressure generating chambers **12**. The ink supply paths **14** have a width narrower than that of the pressure generating chambers **12** and keep a flow path resistance of ink flowing from the communication sections **13** into the pressure generating chambers **12** to be constant. In this embodiment, although the ink supply paths **14** are formed by narrowing the width of the flow path from one side, the ink supply path **14** may be formed by narrowing the width of the flow path from both sides. Alternatively, the ink supply path **14** may be formed by narrowing the thickness instead of the width of the flow path. The communication paths **15** are formed by providing the walls **11** on both sides of the pressure generating chambers **12** in the width direction with the walls **11** extending on the side of the communication sections **13** and separating spaces between the ink supply paths **14** and the communications sections **13**. That is, the flow path forming substrate **10** has the ink supply paths **14** that have a cross-sectional area smaller than that of the pressure generating chambers **12** in the first direction X, and the communication paths **15** that communicate with the ink supply paths **14** and have a cross-sectional area larger than that of the ink supply paths **14** in the first direction X, which are separated by a plurality of walls **11**. In this embodiment, the pressure generating chambers **12**, the communication sections **13**, the ink supply paths **14** and the communication paths **15** are provided on the flow path forming substrate **10** as the flow paths that communicate with the nozzle openings **21**. In this embodiment, the pressure generating chambers **12**, the communication sections **13**, the ink supply paths **14**, the communication paths **15** and the manifolds **100** (manifold sections **31**), which will be described in detail later, are collectively referred to as downstream flow paths.

Further, a nozzles plate **20** is attached on an opening side of the flow path forming substrate **10** by an adhesive, heat-welded film and the like. The nozzle openings **21** that penetrate the nozzles plate **20** are formed in the vicinity of one end of the pressure generating chambers **12** which is opposite to the ink supply paths **14** in the second direction Y. In this embodiment, since two rows of the pressure generating chambers **12** are disposed on the flow path forming substrate **10**, each ink jet recording head **2** has two nozzle rows in which the nozzle openings **21** are arranged side by side. Further, in this embodiment, the cover head **150** covers the surrounding area of the nozzle openings **21** of the nozzles plate **20**. A surface of the nozzles plate **20** to which the nozzle openings **21** are open through the cover head **150** is referred to as the liquid ejection surface **22**.

An elastic film **50** is disposed on a surface of the flow path forming substrate **10** which is opposite to the nozzles plate **20**, and an insulator film **55** is disposed on the elastic film **50**. Further, first electrodes **60**, piezoelectric layers **70** which are piezoelectric material that perform electromechanical conversion and second electrodes **80** are stacked on the insulator film **55** in sequence and constitute piezoelectric actuators **300** which are pressure generating means of this embodiment. Accordingly, each piezoelectric actuator **300** includes the first electrode **60**, the piezoelectric layer **70** and the second electrode **80**. In general, one of the electrodes of the piezoelectric actuator **300** is used as a common electrode, and the other of the electrodes and the piezoelectric layer **70** are patterned for each of the pressure generating chambers **12**. Further, a portion which is formed by one of the electrodes and the piezoelectric layer **70** which are patterned and has a piezoelectric strain due to application of a voltage to both electrodes is referred to as a piezoelectric active portion. In this embodiment, the first electrode **60** on the side of the flow path forming substrate **10** is used as the common electrode of the piezoelectric actuator **300**, and the second electrode **80** is used as an individual electrode of the piezoelectric actuator **300**, although the first electrode **60** and the second electrode **80** may be used as the individual electrode and the common electrode, respectively, for convenience of the drive circuit and wiring. In the above example, the elastic film **50**, the insulator film **55** and the first electrode **60** are configured to serve as a vibration plate. However, the invention is not limited thereto, and for example, a configuration is possible in which only the first electrode **60** serves as the vibration plate without the elastic film **50** and the insulator film **55**. Alternatively, the piezoelectric actuator **300** itself may substantially serve as the vibration plate.

Each second electrode **80** which is the individual electrode of the piezoelectric actuator **300** is connected to a lead electrode **90** (connection terminal) that extends to the insulator film **55**. The lead electrode **90** has one end that is connected to the second electrode **80** and the other end that extends to a position between the rows of the piezoelectric actuators **300**. That is, the other end of the lead electrode **90** extends to a position between the piezoelectric actuators **300** which are adjacent in the second direction Y. The other end of the lead electrode **90** is connected to the drive wiring **101**.

The protective substrate **30** that has the manifold sections **31** which form at least part of the manifolds **100** is attached on the flow path forming substrate **10** which has the piezoelectric actuators **300**, that is, on the first electrodes **60**, the insulator film **55** and the lead electrodes **90**, via an adhesive **35**. In this embodiment, the manifold sections **31** extend in the width direction of the pressure generating chambers **12** and penetrate the protective substrate **30** in the thickness direction. The manifold sections **31** communicate with the communication sections **13** of the flow path forming substrate **10** as described above so as to form the manifold **100** which serve as the common ink chamber of the pressure generating chambers **12**. Although the communication sections **13** which form the manifolds **100** are disposed on the flow path forming substrate **10** in this embodiment, the invention is not limited thereto. For example, the communication sections **13** of the flow path forming substrate **10** may be separated for each of the pressure generating chambers **12** so that only the manifold sections **31** serve as the manifold. Further, for example, only the pressure generating chambers **12** may be formed on the flow path forming substrate **10** and the ink supply paths **14** that connect the manifolds and the pressure generating chambers **12** may be disposed on a member located between the flow path forming substrate **10** and the protective substrate (for example, the elastic film **50**, the insulator film **55** and the like).

Further, piezoelectric actuator holding section **32** are disposed on the protective substrate **30** at positions opposite the piezoelectric actuators **300**. The piezoelectric actuator holding sections **32** are spaces that do not interfere with the movement of the piezoelectric actuators **300**. The piezoelectric actuator holding sections **32** may or may not be closed as long as having spaces that do not interfere with the movement of the piezoelectric actuators **300**. In this embodiment, since two rows of the piezoelectric actuators **300** are disposed, the piezoelectric actuator holding sections **32** are provided for each of the rows of the piezoelectric actuators **300**. That is, two rows of the piezoelectric actuator holding sections **32** are arranged in the second direction Y on the protective substrate **30**.

The protective substrate **30** also has a through hole **33** that penetrates the protective substrate **30** in the thickness direction. In this embodiment, the through hole **33** is disposed between two piezoelectric actuator holding sections **32** such that the vicinity of the end of the lead electrodes **90** which are led out from the piezoelectric actuator **300** are exposed in the through hole **33**.

A drive circuit **102** such as a drive IC that actuates the piezoelectric actuators **300** is mounted on the flexible drive wiring **101**. That is, the drive wiring **101** is formed of a COF or the like on which the drive circuit **102** is mounted.

As shown in FIGS. **9**A and **9**B, a compliance substrate **40** which is composed of a sealing film **41** and a fixation plate **42** is attached on the protective substrate **30**. The sealing film **41** is made of a flexible material having a low rigidity (for example, polyphenylene sulfide (PPS) film) and closes one side of the manifold sections **31**. The fixation plate **42** is made of a rigid material such as a metal (for example, stainless steel (SUS)). Since regions of the fixation plate **42** which oppose the manifolds **100** are openings **43** that penetrate the fixation plate **42** in the thickness direction, one side of the manifolds **100** is sealed by only the flexible sealing film **41**. Further, the compliance substrate **40** has introduction ports **44** that supply ink to the manifolds **100** and discharge ports **45** that discharge ink from the manifolds **100**. The introduction ports **44** and the discharge ports **45** are disposed at each end of the manifold sections **31** of the manifolds **100** in the first direction X.

A head case **105** is mounted on the compliance substrate **40**. The head case **105** has relief sections **106** in a concave shape at positions which correspond to the openings **43** so as to allow the openings **43** to flexibly deform as appropriate. Further, the head case **105** has an insertion hole **107** that communicates with the through hole **33** of the protective substrate **30**. The drive wiring **101** is inserted into the insertion hole **107** and the through hole **33** with the lower end of the drive wiring **101** being connected to the lead electrodes **90**.

The head case **105** also has third supply paths **202** that communicate with the introduction ports **44** and supply ink from the second supply paths **201** of the flow path member **120** to the manifolds **100**, and third discharge paths **212** that communicate with the discharge ports **45** and discharge ink to the second discharge paths **211** of the flow path member **120**. That is, as shown in FIG. **2**, in this embodiment, each supply path that supplies ink from the liquid storing unit **6** to the manifold **100** includes the first supply path **200** of the supply tube **7**, the second supply path **201** of the flow path member

120, the third supply path **202** of the head case **105** and the introduction port **44**. Further, each discharge path that discharges ink from the manifold **100** to the liquid storing unit **6** includes the discharge port **45**, the third discharge path **212** of the head case **105**, the second discharge path **211** of the flow path member **120** and the first discharge path **210** of the discharge tube **8**.

In this embodiment, the flow path resistance of the discharge flow path from the manifold **100** is smaller than the flow path resistance of the supply flow path from the pump unit **9** to the manifold **100**.

The flow path resistance of the discharge flow path in this embodiment is a flow path resistance of the discharge path (the entire discharge path) that discharges ink from the manifolds **100** of the respective ink jet recording heads **2** to the liquid storing unit **6**. In the case where the discharge path is not connected to the liquid storing unit **6** and ink is discharged to the outside or the like, the flow path resistance of the discharge path is a flow path resistance to the discharge port.

The flow path resistance of the supply flow path is a flow path resistance of a portion of the supply path that supplies ink from the liquid storing unit **6** to the manifolds **100** which extends from the pump unit **9** to the manifolds **100**.

That is, in this embodiment, the flow path resistance (pressure loss) of the discharge path (the entire discharge path) that discharges ink from the manifolds **100** of the respective ink jet recording heads **2** to the liquid storing unit **6** is smaller than the flow path resistance (pressure loss) of a portion of the supply path that supplies ink from the liquid storing unit **6** to the manifolds **100** which extends from the pump unit **9** to the manifolds **100**.

More specifically, as described above, the discharge path (the entire discharge path) that discharges ink from the manifolds **100** to the liquid storing unit **6** refers to the discharge port **45**, the third discharge path **212**, the second discharge path **211** and the first discharge path **210**. Further, the supply path which extends from the pump unit **9** to the manifolds **100** refers to a portion of the first supply path **200** which extends from the pump unit **9** to the ink jet recording heads **2**, the second supply path **201**, the third supply path **202** and the introduction port **44**. In this embodiment, the filter **124** that traverses the flow path is disposed at a position in the supply path between the pump unit **9** and the manifolds **100**, more specifically, in the second supply path **201**. Accordingly, the filter **124** causes the flow path resistance of the supply path which extends from the pump unit **9** to the manifolds **100** to be larger than that of the discharge path.

As a matter of course, adjustment of the flow path resistance is not limited to the use of the filter **124**. The flow path resistance of the discharge path may be adjusted to be smaller than the flow path resistance of the supply path which extends from the pump unit to the manifolds by adjusting the cross-sectional area of the flow path. That is, the flow path resistance of the discharge path may be smaller than the flow path resistance of the supply path by increasing the cross-sectional area of the discharge path to be larger than the cross-sectional area of the supply path. In addition, both the pressure loss of the filter **124** and the cross-sectional area of the flow path can be adjusted, or alternatively, the flow path resistance can be adjusted by using any other methods.

Accordingly, when the flow path resistance of the discharge path from the manifolds **100** to the liquid storing unit **6** is smaller than the flow path resistance of the supply path from the pump unit **9** to the manifold **100**, the pressure in the manifolds **100** can be stabilized by preventing the pressure in the manifolds **100** from varying even if the amount of ink droplets ejected from the nozzle openings **21** changes. In other words, in one ink jet recording head **2**, the consumption of ink differs between when ink droplets are ejected from one nozzle opening **21** and when ink droplets are ejected from all the nozzle openings **21**. If the flow path resistance of the discharge path is large, the pressure in the manifolds **100** varies depending on the consumption of ink ejected at a time. Accordingly, the pressure change in the manifolds **100** due to the difference in the consumption of ink causes the difference in the weight of ejected ink droplets, which causes uneven ink application (uneven printing) on the recording sheet S. In particular, in the nozzle openings **21** that eject the ink droplets of the same color, the difference in the weight of ejected ink droplets often causes streaky unevenness of ink application. In this embodiment, the pressure change in the manifolds **100** due to the difference in the consumption of ejected ink can be reduced by decreasing the flow path resistance of the discharge path. Accordingly, the difference in the weight of the ejected ink droplets can be reduced regardless of the number of nozzle openings **21** that eject ink droplets at a time. As a result, the uneven ink application on the recording sheet S can be prevented.

The ink jet recording heads **2** are arranged such that the arrangement direction of the nozzle openings **21**, the first direction X, is perpendicular to the transportation direction of the recording sheet S. The rows of the nozzle openings **21** are continuous in the arrangement direction of the ink jet recording head **2**. Since the rows of the nozzle openings **21** of the plurality of ink jet recording heads **2** are positioned to be continuous in the direction that is perpendicular to the transportation direction, it is possible to perform printing on the recording sheet S having a large width by using the nozzle rows of short length. In this embodiment, the first supply path **200** of the supply tube **7** that supplies ink in the liquid storing unit **6** is divided into branches so that ink of the same color (the same type liquid) is supplied to the plurality of ink jet recording heads **2**. That is, in the line-type ink jet recording apparatus I of this embodiment in which the nozzle openings **21** are arranged to be continuous in the direction that is perpendicular to the transportation direction of the recording sheet S and ink of the same color (the same type liquid) is supplied to the plurality of ink jet recording heads **2**, the difference in the pressure in the manifolds **100** of the different ink jet recording heads **2** can be reduced by decreasing the flow path resistance of the discharge path as described above, thereby reducing the difference in the weight of ink and preventing the streaky unevenness of ink application which occurs particularly during ejection of the ink of the same color.

Further, in this embodiment, ink which is pressurized by the pump unit **9** is supplied to the ink jet recording heads **2**. Accordingly, ink can be supplied under a higher pressure than in the case where ink is supplied from the liquid storing unit **6** to the manifold **100** under a negative pressure by using a suction pump or the like which is disposed in the discharge path. That is, a meniscus at the nozzle opening **21** may be broken by a high suctioning pressure when ink is supplied by suctioning (under a negative pressure), while ink can be supplied under a high pressure when ink is supplied by pumping (under a positive pressure). Accordingly, when ink is supplied under a relatively high pressure by using a pump unit **9**, air bubbles attached on the filter **124** can be discharged. Therefore, the ink jet recording head **2** can be reduced in size by decreasing an effective area of the filter **124**.

Other Embodiments

Although one embodiment of the invention has been described above, the essential configuration of the invention is not limited to the above-mentioned embodiment.

For example, a refilling unit may be provided so as to refill ink into the liquid storing unit of the first embodiment. An example of the refilling unit is shown in FIG. **10**. FIG. **10** is a sectional view which shows a schematic configuration of the ink jet recording apparatus.

As shown in FIG. **10**, the ink jet recording apparatus I of this embodiment includes the ink jet recording head **2**, the liquid storing unit **6** that stores ink and a refilling unit **400** that refills liquid into the liquid storing unit **6**.

The liquid storing unit **6** is configured to store ink and is movable upward and downward in the vertical direction relative to the ink jet recording head **2**. Although not shown in the figure, a moving unit that moves the liquid storing unit **6** upward and downward in the vertical direction is also provided. The moving unit includes, for example, a device that uses a motor, hydraulic pressure and electromagnetic force.

The refilling unit **400** is provided as a storage tank or the like that stores ink and supplies ink to the liquid storing unit **6**. Specifically, the refilling unit **400** is connected to the liquid storing unit **6** via a refilling tube **402** having a refilling path **401** in the refilling tube **402**. The refilling unit **400** refills the liquid storing unit **6** with ink when ink is consumed by being ejected as ink droplets from the ink jet recording head **2**. Although not shown in the figure, a liquid level sensor that detects ink consumption in the liquid storing unit **6**, a valve that opens/closes the refilling path **401** in response to the information from the liquid level sensor are also provided.

In the ink jet recording apparatus I, the moving unit moves the liquid storing unit **6** upward and downward in the vertical direction relative to the ink jet recording head **2**. This changes a height h from the liquid level of the ink stored in the liquid storing unit **6** to the liquid ejection surface to which the nozzle openings of the ink jet recording head **2** are open, which causes a change in water head pressure and a change in negative pressure during discharge from the manifolds **100** to the liquid storing unit **6**. Accordingly, the position of liquid meniscus at the nozzle openings **21** can be adjusted by adjusting the pressure in the manifold **100**.

Then, when ink is consumed by being ejected as ink droplets from the ink jet recording head **2**, ink is refilled into the liquid storing unit **6** by the refilling unit **400**.

In the configuration shown in FIG. **10**, the pressure change in the manifolds **100** can be reduced by decreasing the flow path resistance of the discharge path to be smaller than the flow path resistance of the supply path which extends from the pump unit **9** to the manifolds **100**, thereby reducing the difference in the weight of ejected ink droplets. As a matter of course, a moving unit may be provided in the liquid storing unit **6** of the first embodiment. In the example shown in FIG. **10**, ink meniscus at the nozzle opening **21** is adjusted by using the water head difference when the moving unit moves the liquid storing unit **6** upward and downward in the vertical direction, although the invention is not limited thereto. For example, the meniscus may be adjusted by a pressure of a negative pressure pump which is provided at a position in the discharge path, or a water level in the liquid storing unit **6** may be detected by using a sensor so that refilling unit **400** refills the liquid storing unit **6** with ink in response to decrease of the water level.

In the first embodiment, the circulation flow path is described in which ink in the liquid storing unit **6** is supplied to the ink jet recording heads **2** through the supply path and ink supplied to the ink jet recording heads **2** is discharged in the same liquid storing unit **6**, although the invention is not limited thereto. For example, a supply liquid storing unit for storing ink to be supplied and a discharge liquid storing unit for storing ink to be discharged may be separately provided. Alternatively, the discharged ink may be disposed, not being stored. In addition, the circulation flow path can be formed by connecting the supply liquid storing unit and the discharge liquid storing unit.

In the first embodiment, the pressure generating unit that generates a pressure change in the pressure generating chamber **12** has been explained as a thin film type piezoelectric element **300**, although the pressure generating unit is not specifically limited thereto. For example, a thick film type piezoelectric actuator that is formed by bonding a green sheet or a vertical vibration-type piezoelectric actuator that is formed by alternately stacking a piezoelectric material and an electrode forming material so as to expand and contract in the axial direction can also be used. Further, as a pressure generating unit, a heat generating element may be disposed in the pressure generating chamber so as to generate bubbles by heat from the heat generating element, thereby ejecting liquid droplets from the nozzle openings, or a so-called static actuator may be used to generate static electricity between the vibration plate and the electrode so as to deform the vibration plate by electrostatic force, thereby ejecting liquid droplets from the nozzle openings.

In the first embodiment, the ink jet recording apparatus I has been described as a so-called line type recording apparatus in which the ink jet recording head **2** (head unit II) is mounted at a fixed position on the apparatus body **4** and printing is performed only by transporting the recording sheet S, although the ink jet recording apparatus I is not limited thereto. For example, the invention can be applied to a so-called serial type ink jet recording apparatus in which the ink jet recording head (head unit II) is mounted on the carriage that moves in the main scan direction which is perpendicular to the transportation direction of the recording sheet S so that printing is performed while the ink jet recording head **2** moves in the main scan direction.

Further, the invention is directed to the liquid ejecting apparatuses in general. For example, the invention can be applied to liquid ejecting apparatuses which use recording heads such as various ink jet recording heads used for image recording apparatuses such as a printer, color material ejecting heads used for manufacturing color filters for liquid crystal displays and the like, electrode material ejecting heads used for forming electrode for organic EL displays, field emission displays (FED) and the like, and bioorganic ejecting heads used for manufacturing bio chips and the like.

What is claimed is:

1. A liquid ejecting apparatus comprising:

a liquid ejecting head that ejects liquid in a manifold as liquid droplets from nozzle openings;

a supply path that supplies the liquid to the manifold;

a pump unit that is disposed in the supply path and pumps the liquid to the manifold; and

a discharge path that discharges the liquid from the manifold, wherein a flow path resistance of the discharge path from the manifold is smaller than a flow path resistance of the supply path between the pump unit and the manifold to reduce pressure change in the manifold due to difference in number of the nozzle openings ejecting liquid at a time.

2. The liquid ejecting apparatus according to claim **1**, further comprising a filter that traverses the supply path is disposed in the supply path at a position between the pump unit and the manifold.

3. The liquid ejecting apparatus according to claim **1**, wherein the flow path resistance is adjusted by adjusting an amount of cross-sectional area of the supply path and the discharge path.

4. The liquid ejecting apparatus according to claim **1**, further comprising a liquid storing unit, wherein the pump unit pumps the liquid stored in the liquid storing unit via the supply path, and the discharge path discharges the liquid from the manifold to the liquid storing unit.

5. The liquid ejecting apparatus according to claim **1**, further comprising a supply liquid storing unit, wherein the pump unit pumps the liquid stored in the supply liquid storing unit via the supply path.

6. The liquid ejecting apparatus according to claim **5**, further comprising a discharge liquid storing unit, wherein the discharge path discharges the liquid from the manifold to the discharge liquid storing unit.

7. The liquid ejecting apparatus according to claim **6**, wherein the supply liquid storing unit and the discharge liquid storing unit are connected with each other.

8. The liquid ejecting apparatus according to claim **1**, further comprising a plurality of liquid ejecting heads, wherein the supply path that supplies the liquid from the pump unit to the liquid ejecting head is divided into branches.

9. The liquid ejecting apparatus according to claim **1**, wherein the pump unit is a pump.

10. The liquid ejecting apparatus according to claim **1**, wherein pressure adjustment of a liquid meniscus at the nozzle opening is performed by using a water head difference between a liquid ejection surface to which the nozzle opening is open and the liquid storing unit.

11. The liquid ejecting apparatus according to claim **1**, further comprising a filter disposed in the supply path at a position between the pump unit and the manifold, wherein the filter increases the flow path resistance from the pump unit to the manifold relative to the flow path resistance downstream of the manifold.

12. The liquid ejecting apparatus according to claim **1**, wherein a relatively constant liquid pressure is maintained in the manifold.

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